

Observations of Electron cloud effects (ECE) at KEKB

- Recent solenoid winding work and its effect on ECE -

ICFA - HB2002, FNAL, 11th April, 2002

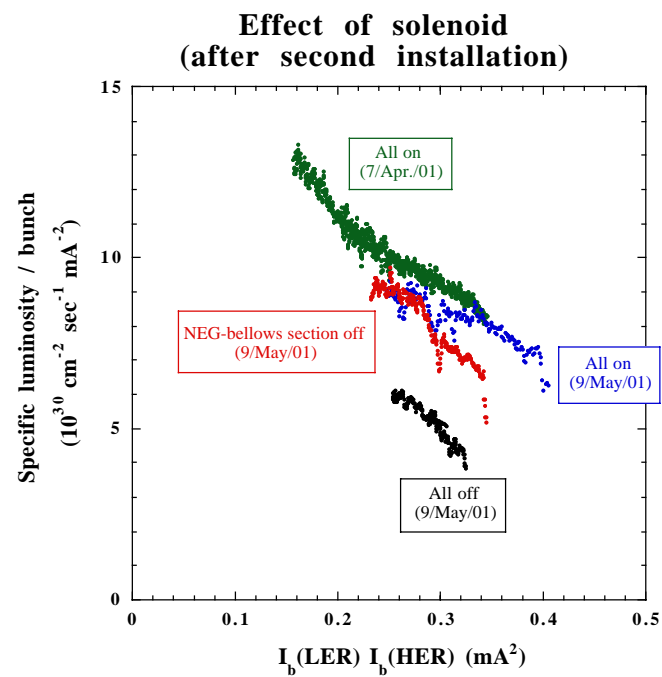
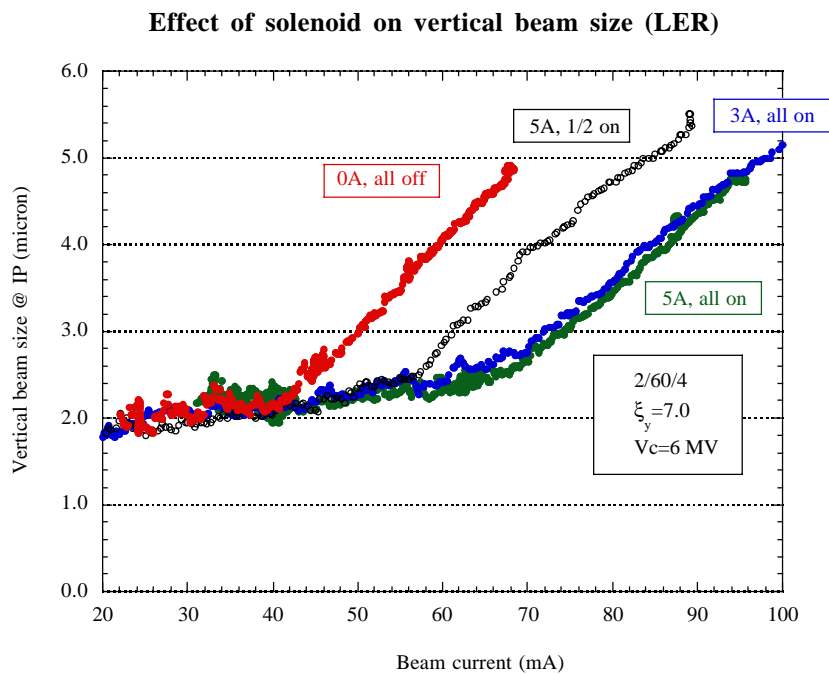
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 - 4) Scaling of threshold current of blowup**
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1. Introduction

- **A large number of solenoids were installed in LER in 2000 to remove the electron cloud which cause the blowup of vertical beam size.**
- **The blowup of beam size was relaxed after installation of solenoid.**
- **The effect of the solenoid on the luminosity was confirmed.**
- **Then the solenoid was added in 2001 summer and 2002 January to suppress the blowup further.**
- **This talk will cover mainly the effect of recently installed solenoid on ECE.**



2. Solenoid winding

Solenoid

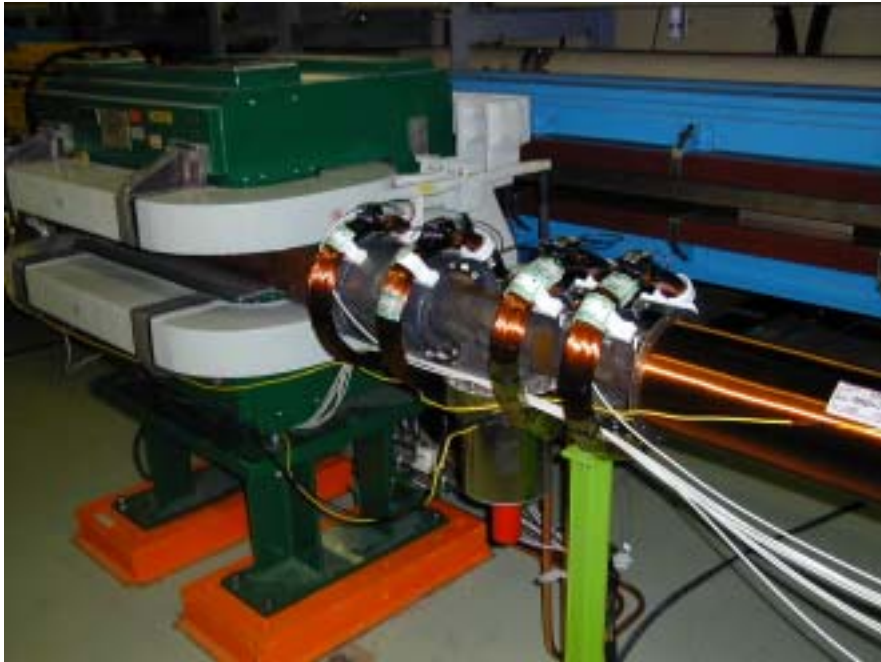
Type	Length (mm)	Diameter (mm)	Turns	Bz (center) @ 5A (Gauss)
Bobbin	150 - 650	148	250(typ.)	45
Bobbinless	40	220	190, 200	48
Bobbinless	40	250	200	43
Bobbinless	40	300	200	37

Power supply(P.S.)

	KEKB corrector P.S.	TRISTAN corrector P.S.
Current(A)	5	3
Units	616	40

Installation history

Date	Bobbinless	Bobbin	Location
2000. 9.	0	2783	Arc section straight section (Cu chamber)
2001. 1.	1950	0	Arc section (Bellows+NEG)
2001. 4.	254	10	Straight section of Fuji andTsukuba (Bellows, Cu chamber)
2001. 9.	3411	43	Straight section (Bellows, Cu chamber) Arc section (NEG,IP, Bellows+NEG)
2002. 1.	119	0	Arc section (Between Quad and Sext)
Total	5734	2836	



NEG pump and Bellows



Ion pump



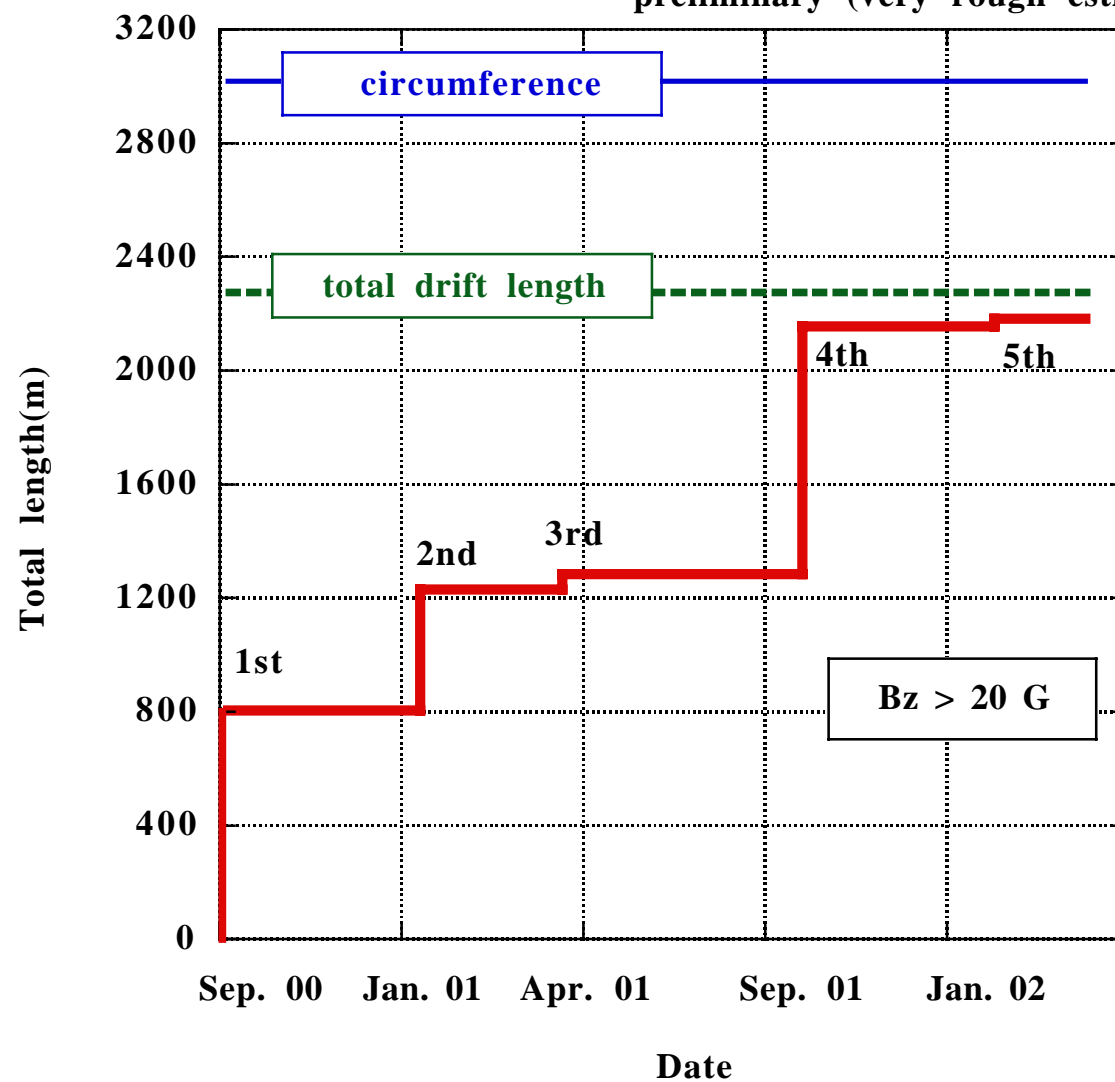
NEG pump



Quad - Sextupole

Total length of solenoid

preliminary (very rough estimation)

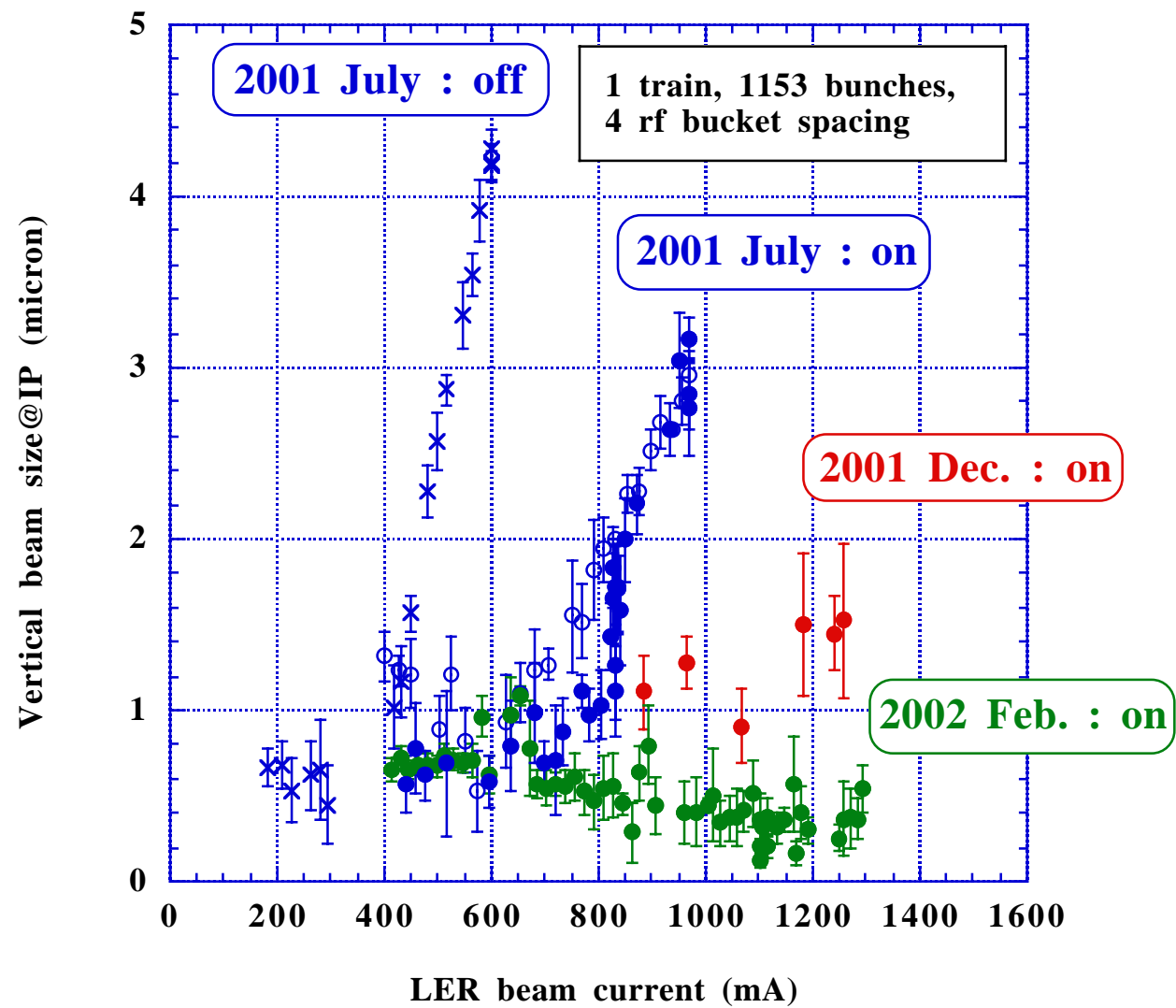


3. Effect of solenoid

1) Beam blowup

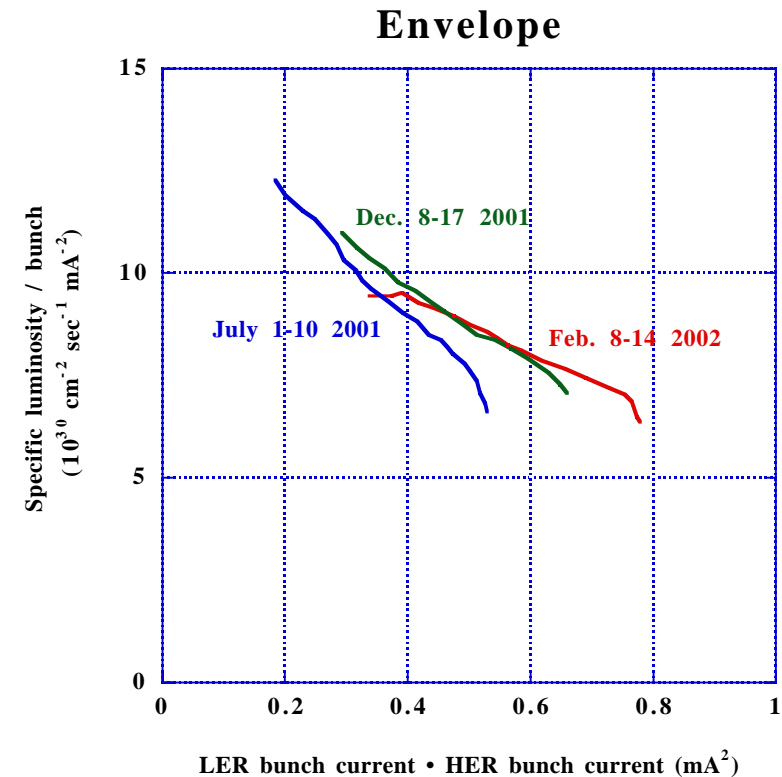
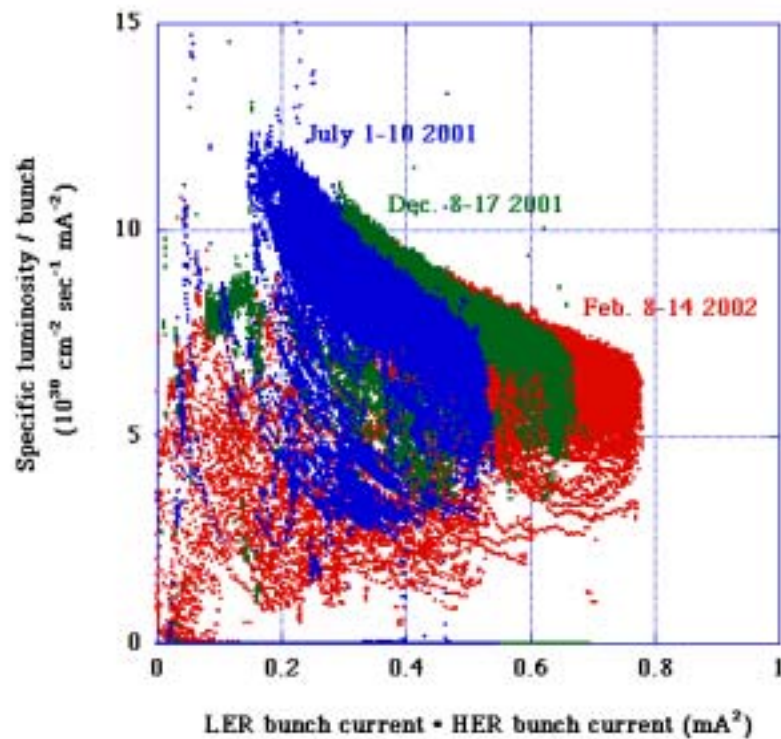
A. Single beam measurement by interferometer

- **Blowup of beam size was disappeared up to 1300mA with 4 rf bucket spacing fill pattern after 5th installation of solenoid at 2001 January.**

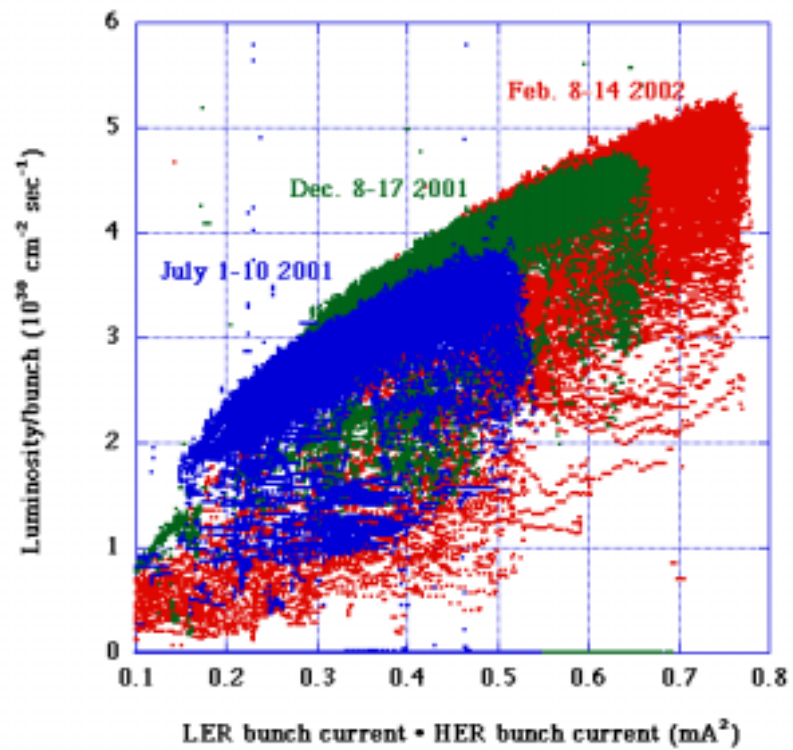


B. Luminosity measurement

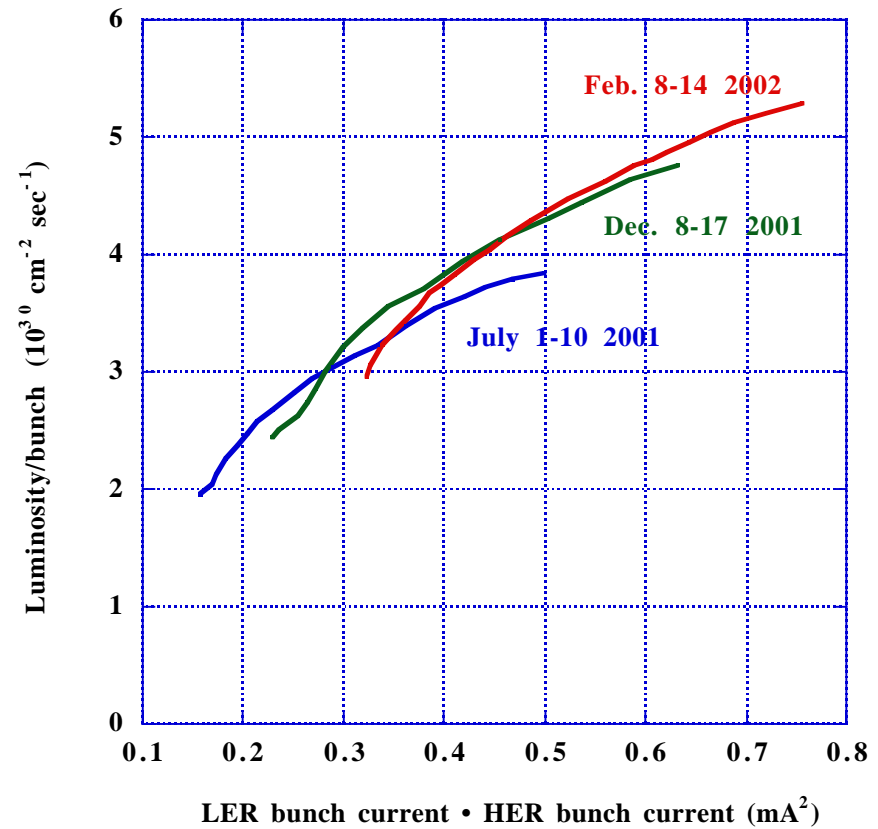
- Specific luminosity and luminosity/bunch were improved after 4th and 5th installation of solenoid.



Luminosity per bunch



Envelope



2) Tune shift along the train

Tune shift by electron cloud

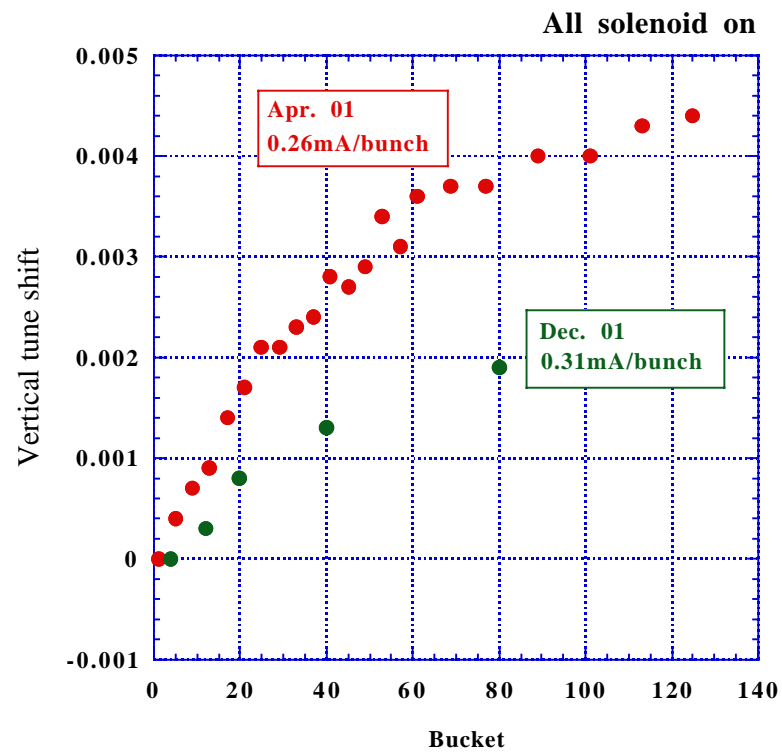
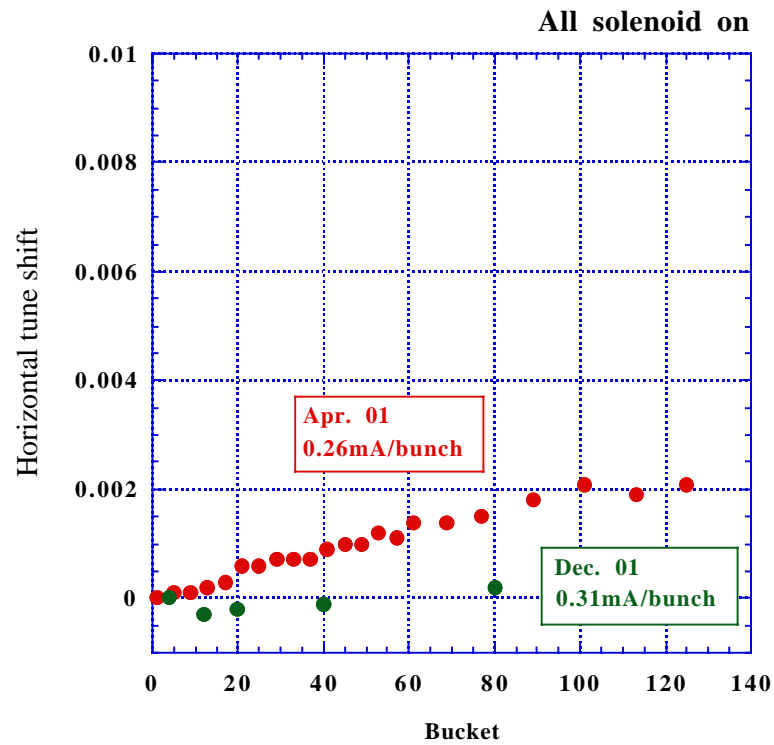
$$\Delta \nu_{x(y)} = \frac{r_0 \langle \beta_{x(y)} \rangle L \rho}{2\gamma}$$

L : ring circumference
 ρ : cloud density
 β : beta function

K. Ohmi et al. shows that above naive formula is valid even taking into account the perturbation to the cloud by the beam.

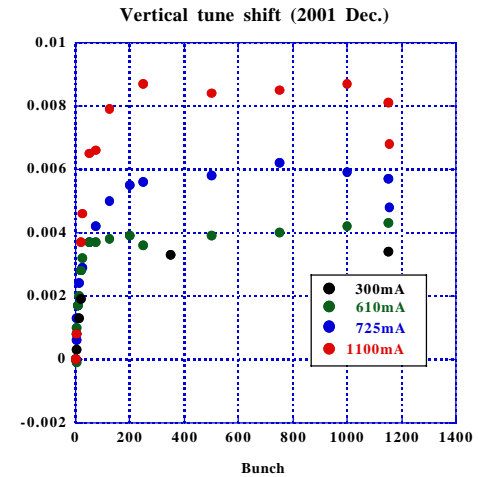
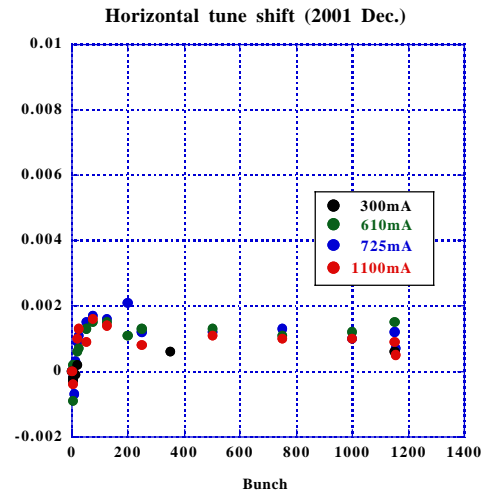
Tune shift is a good measure of cloud density.

- Tune shift along the train measured by gated tune meter(GTM) was decreased after 4th installation of solenoid.

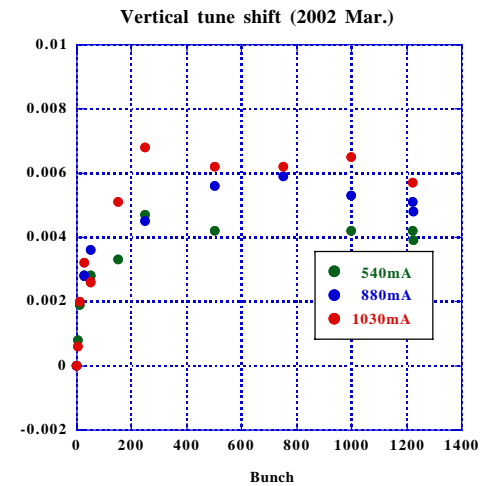
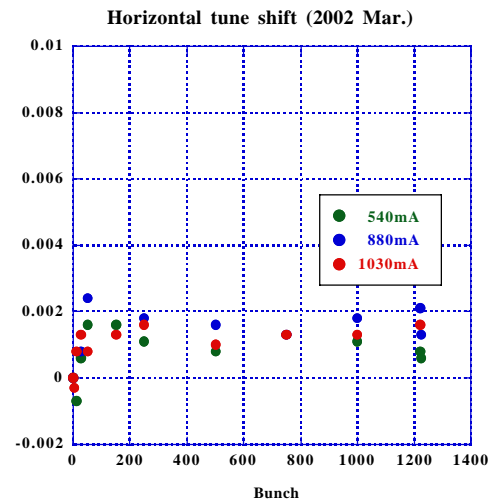


- solenoid on

2001 Dec.

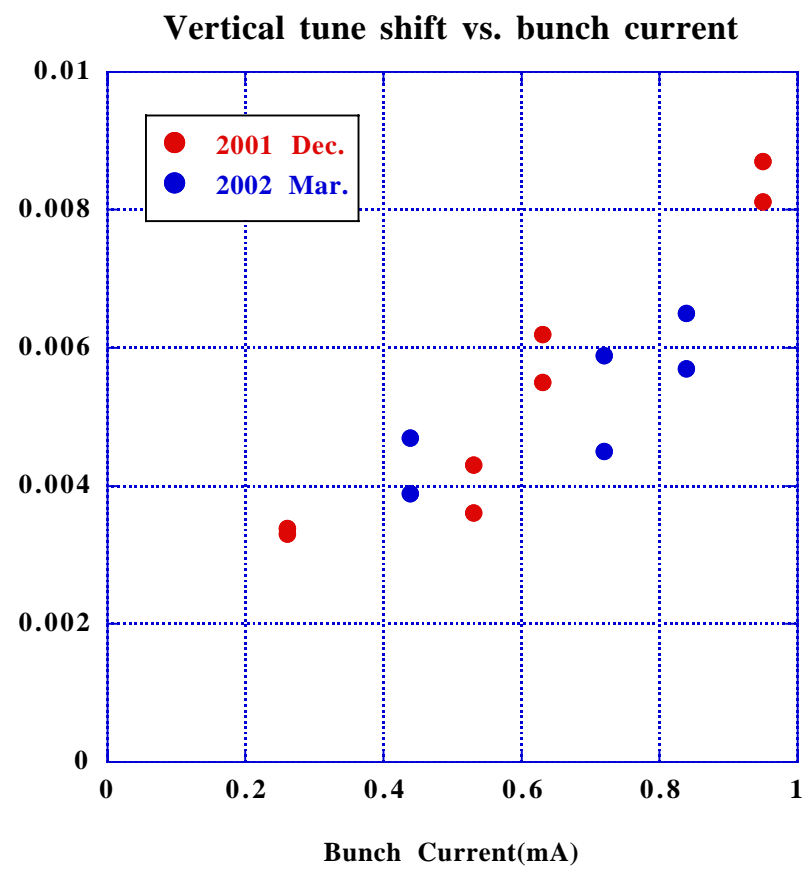


2002 Mar.



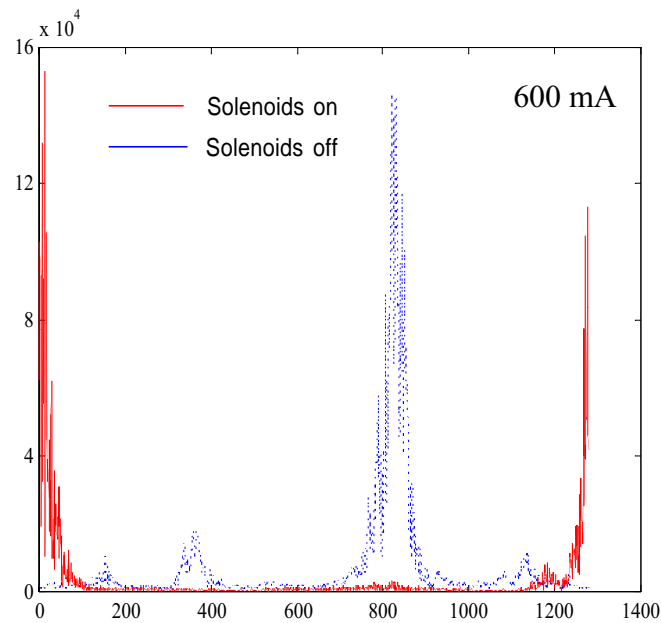
- Vertical tune shift in this March seems to be slightly reduced compared with that in last Dec.
- Horizontal tune shift was not changed.

Does this suggest that cloud distribution is flat ?

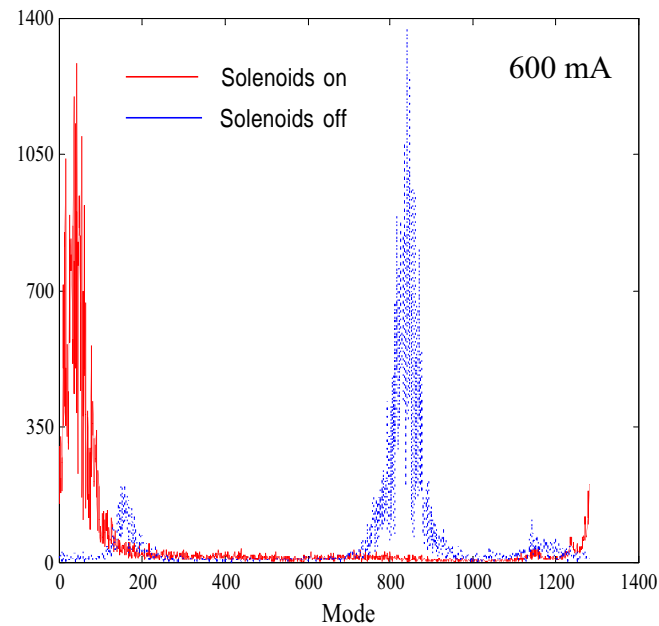


3) Coupled bunch instability

- Coupled bunch instability(CBI) in LER was studied with the Bunch Oscillation Recorder.
- Mode spectrum was changed when the solenoid was excited.



Horizontal

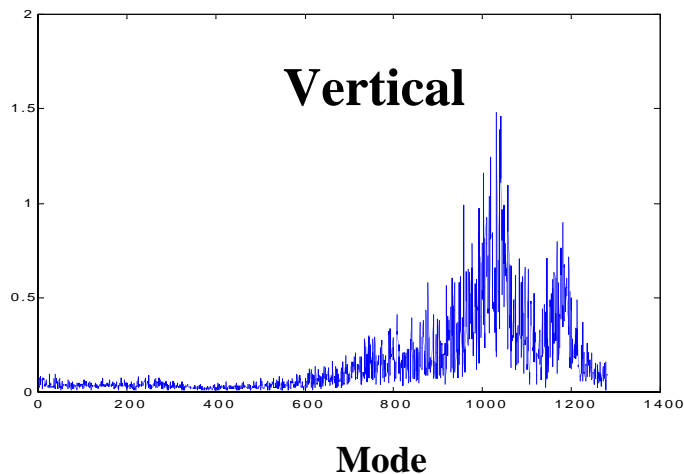
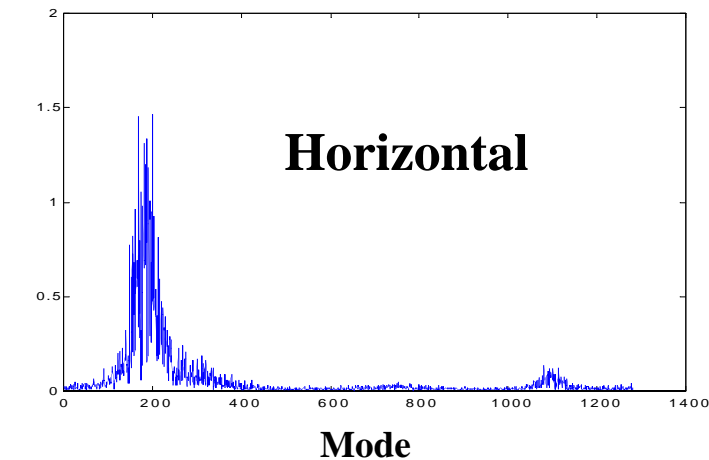


Vertical

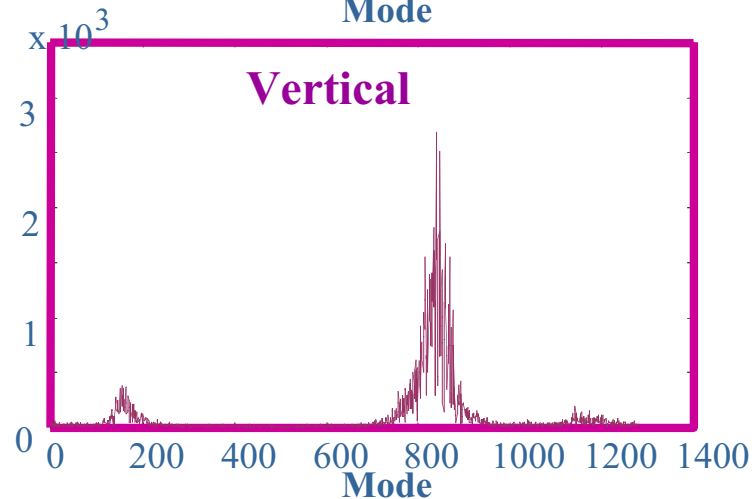
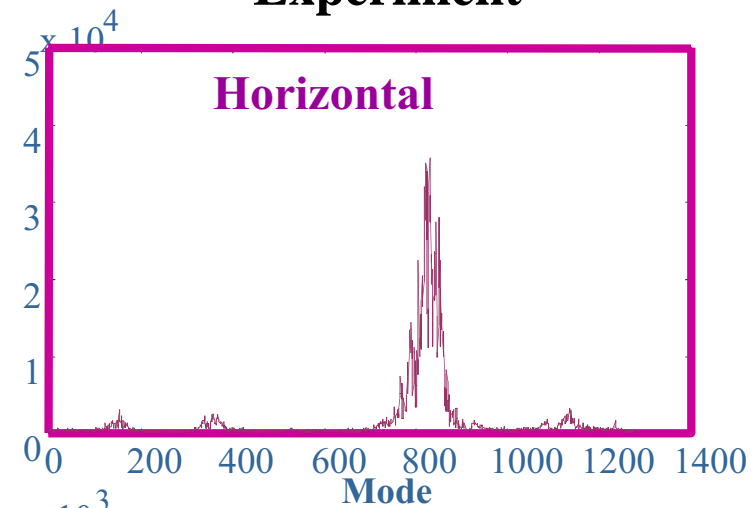
A. Simulation study

- Simulation study of CBI caused by electron cloud is in progress.
- Without solenoid, a result shows a vertical mode spectrum appears at almost same position as that observed, but horizontal one does not.

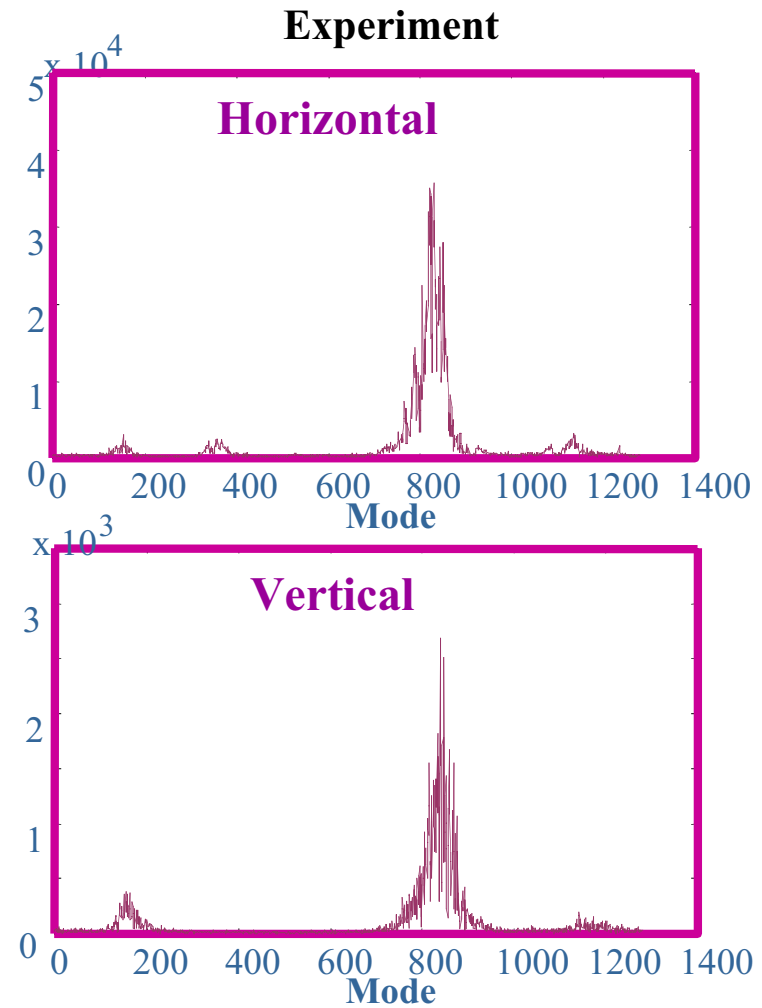
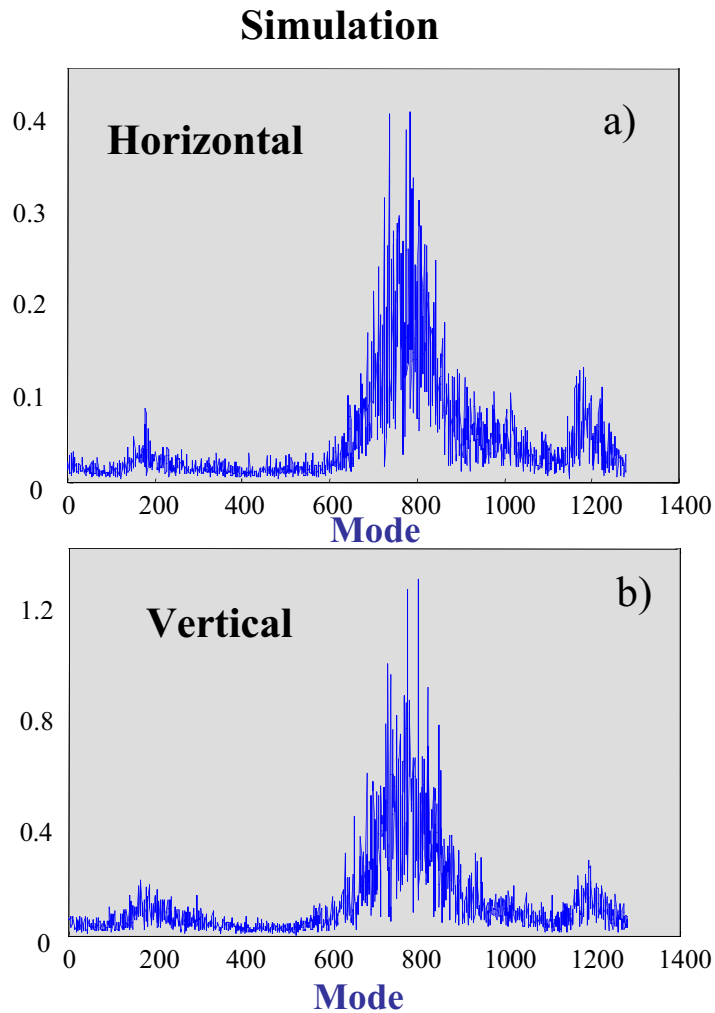
Simulation



Experiment



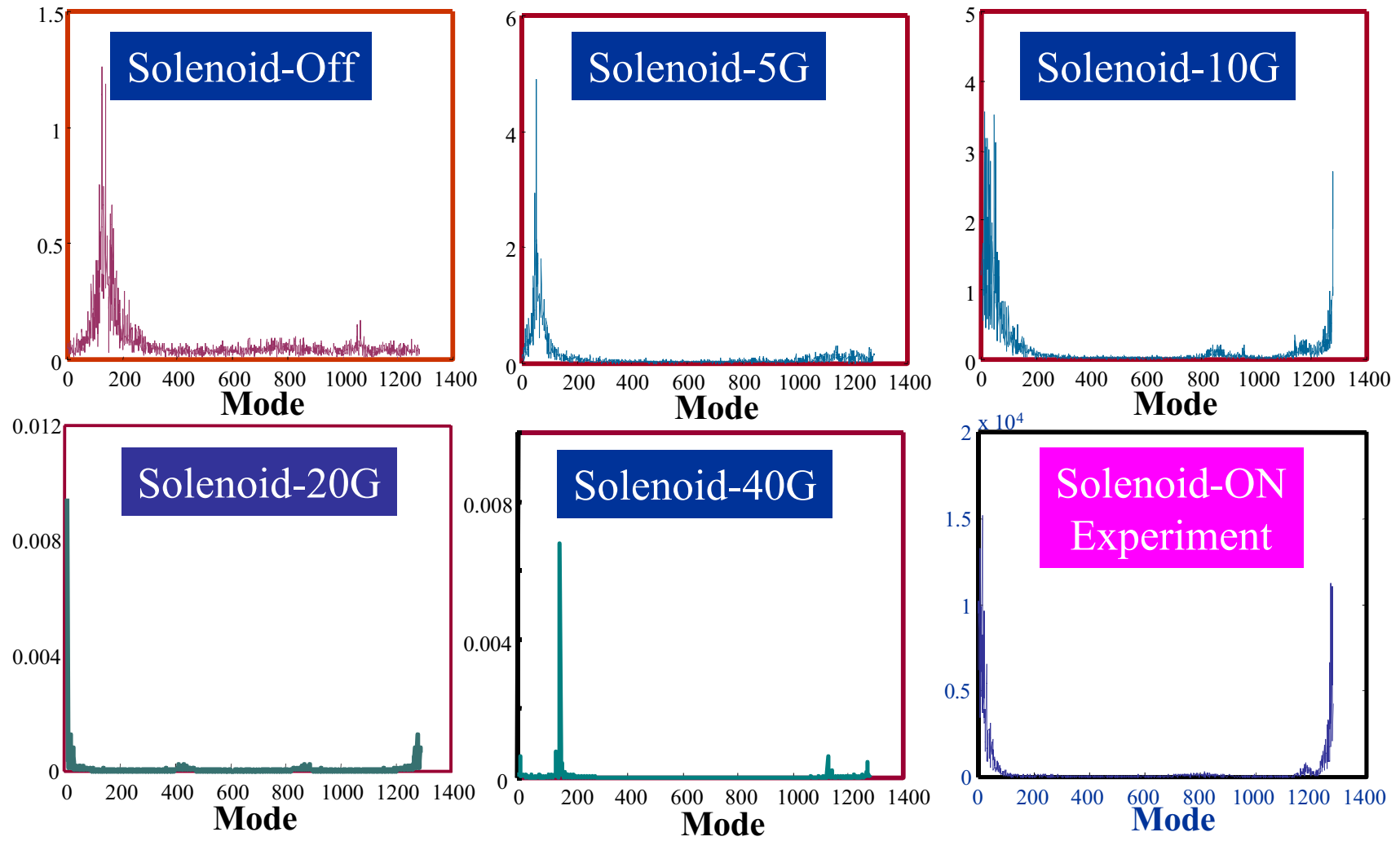
Simulation assumed uniform electron production on the wall (solenoid off)



Simulation suggests round distribution of cloud.

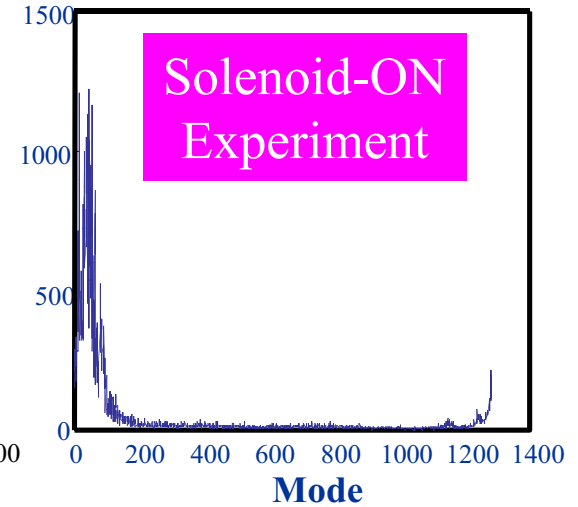
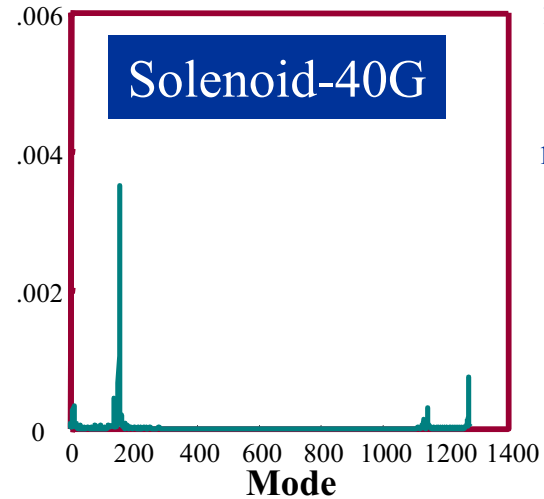
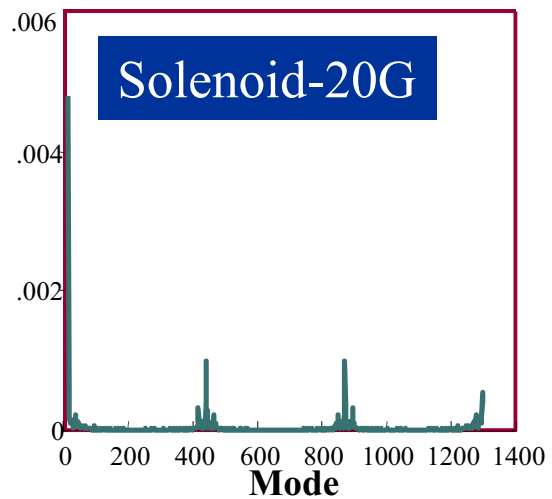
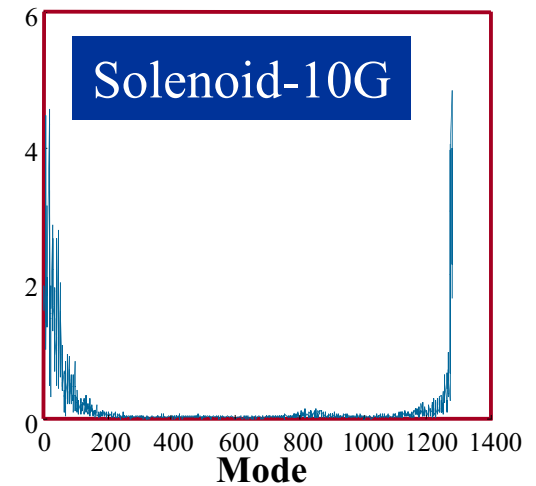
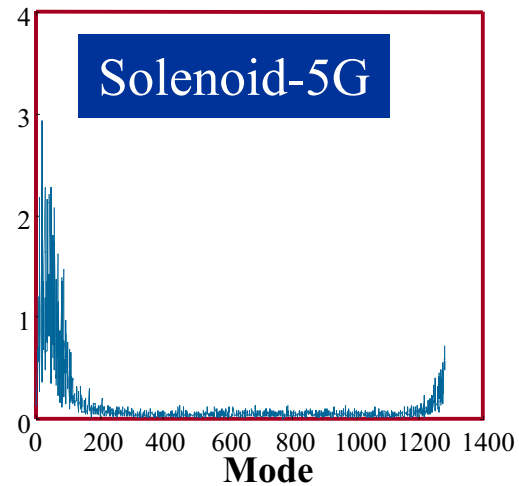
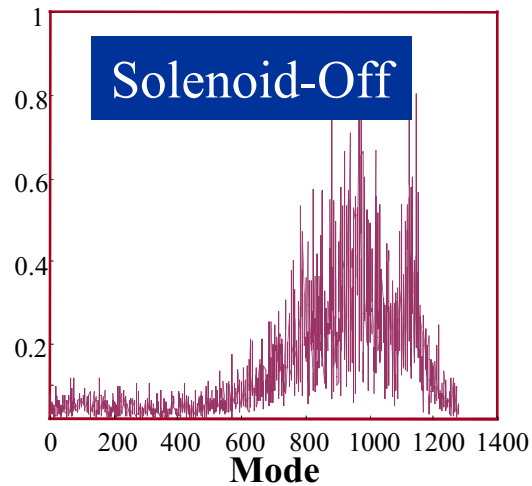
Simulation with solenoid field

Horizontal



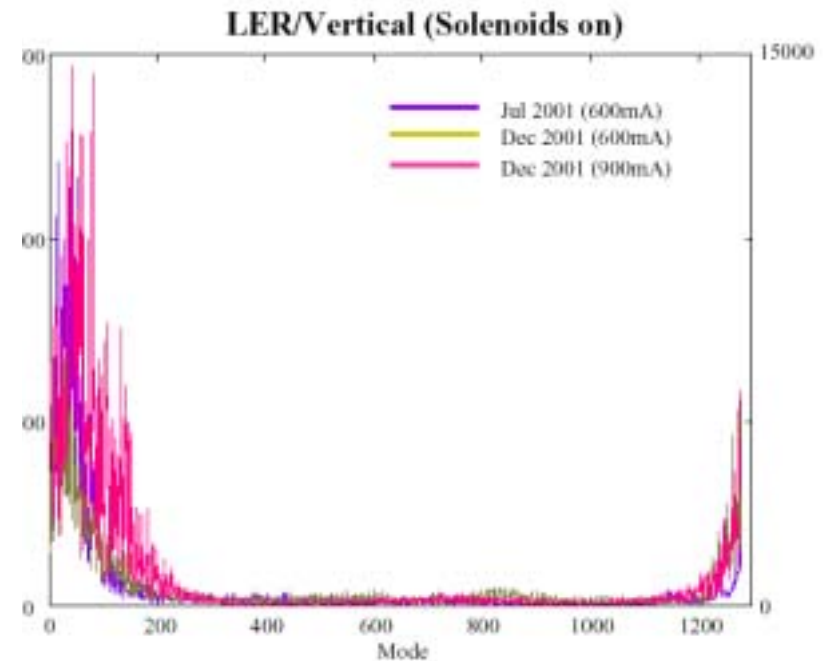
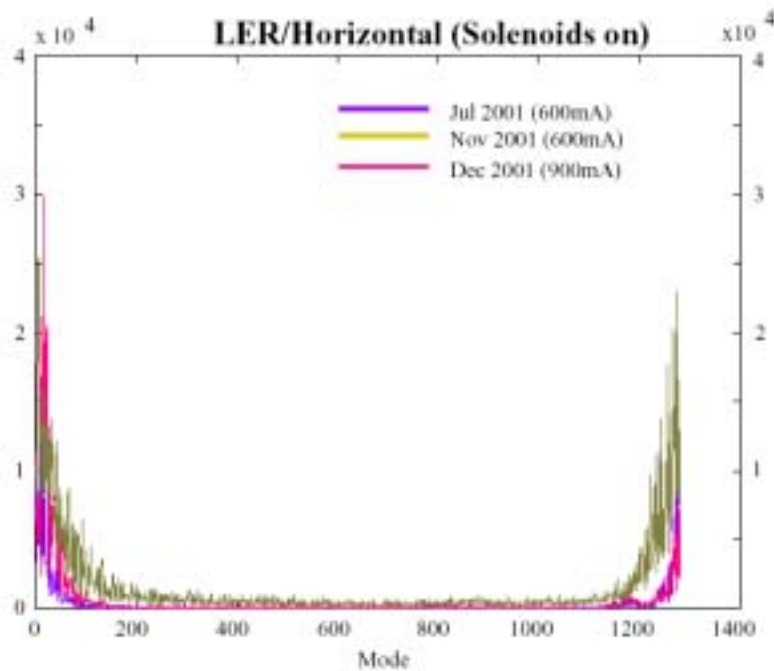
Simulation with solenoid field

Vertical



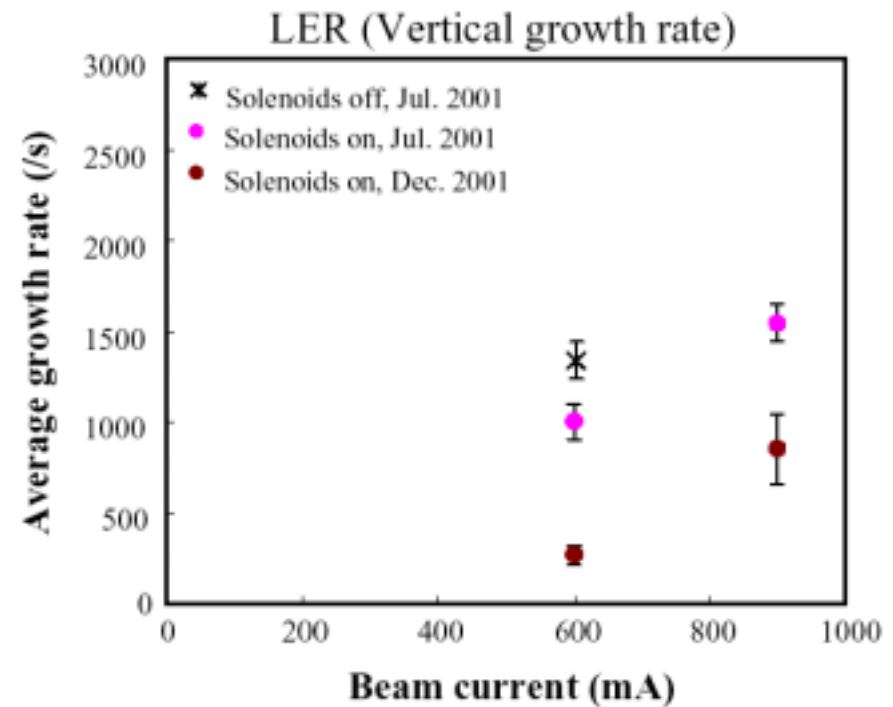
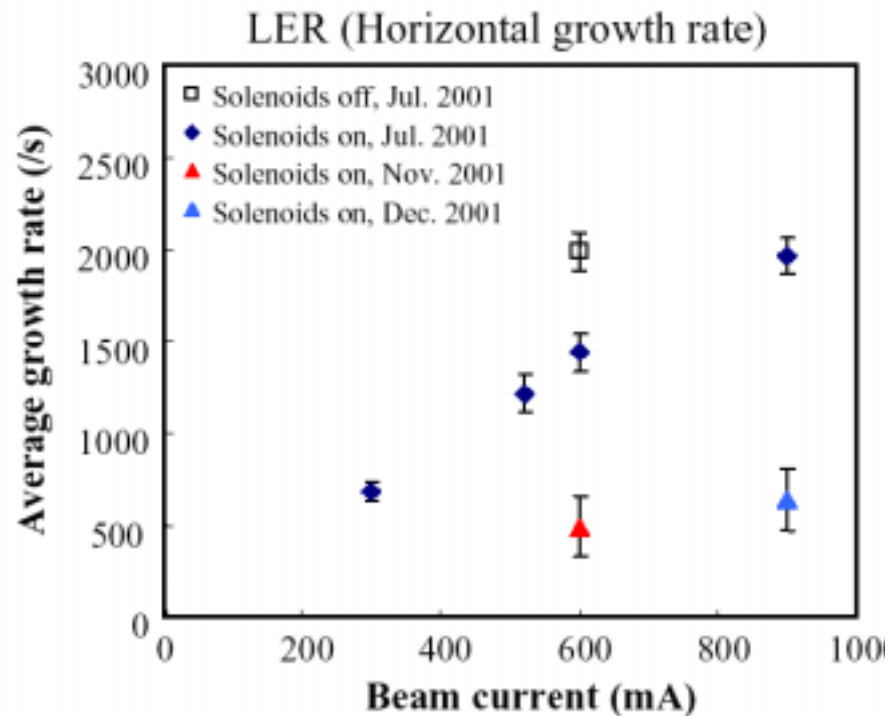
B. Mode spectrum

Mode spectrum did not change much after 4th installation of solenoid. This imply the shape of wake function by electron cloud als....o did not change much.



C. Growth rate

- It was confirmed that growth rate of CBI was reduced when the solenoid was excited.
- Growth rate was reduced by about half after 4th installation of solenoid.



3. Scaling of threshold current of blowup

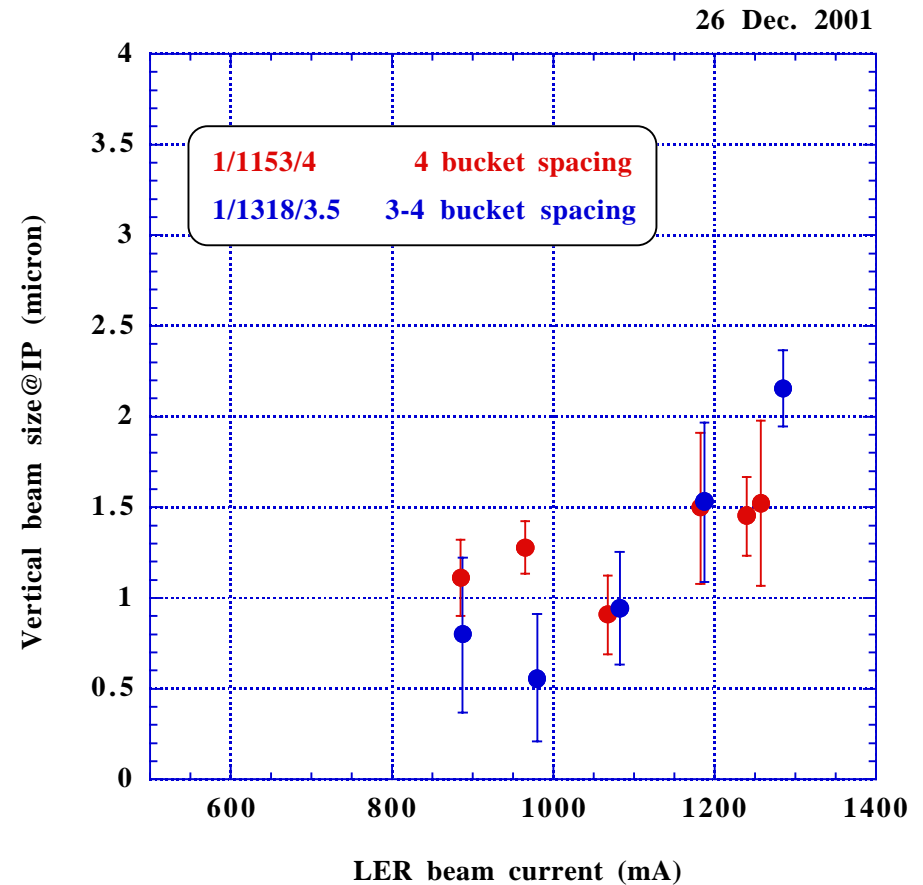
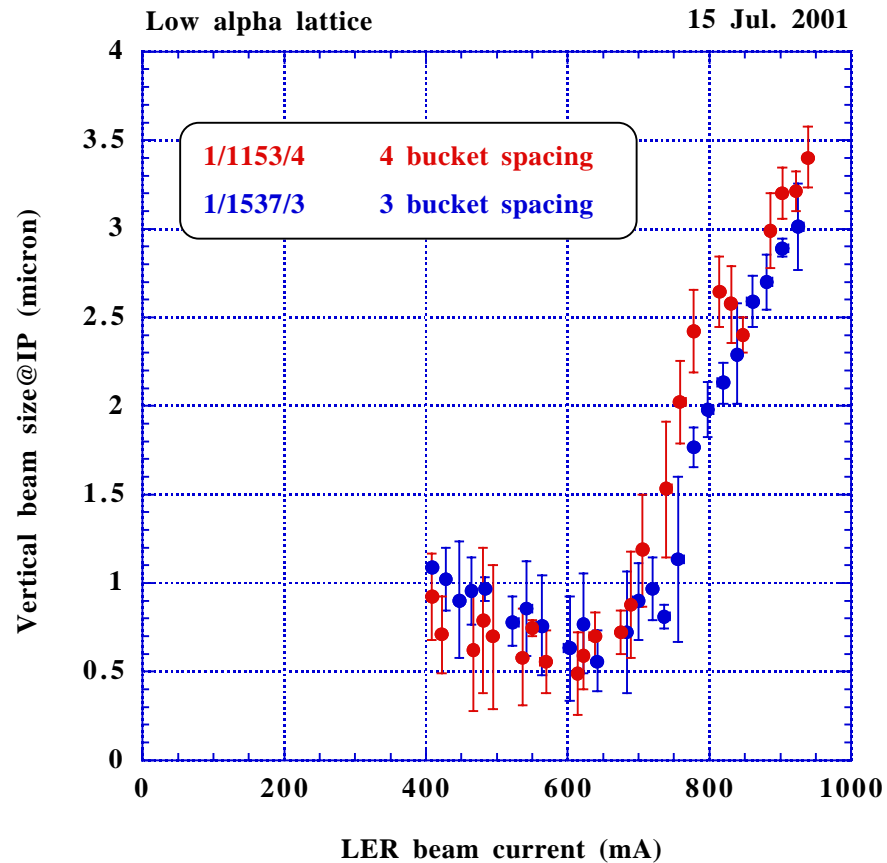
- **Vertical beam size was compared between**
- **4 and 3-4 buckets spacing-fill.**

Fill pattern was arranged to give a same line charge density of the beam (fill pattern: 1/1537/3 and 1/1153/4).

Result showed that blow-up curves were almost same in two fill patterns.

Scaling $I_{b,th} \propto L_{sep.}$ is still valid.

Head-tail, Strong head-tail : $I_{b,th} \propto L_{sep.}$ (Model by F. Zimmermann)



5. Summary

- **Solenoids were added in LER at 2001 September and 2002 January.**

Now solenoid covers about 95% of drift region in LER.

- **After addition of solenoid ECE was studied to see the effect of it.**

Results are summarized as

- 1) Blowup of beam size was disappeared up to 1300mA with 4 rf bucket spacing fill pattern after 5th installation of solenoid.**

Drop of specific luminosity at higher current was improved.

- 2) Tune shift along the train was decreased at least 40% after 4th installation of solenoid.**

- 3) 5th installation of solenoid seems to slightly improve luminosity and tune shift.**

- 4) Growth rate of CBI decreased about half, while mode spectrum was not changed much after 4th installation of solenoid.**
- 5) Scaling of threshold current of blowup vs. bunch spacing is still valid.**